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TESTS ON THE DURABILITY OF GREENHEART

(NECTANDRA RODIAEI SCHOMB.)

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(WITH PLATE 162, CONTAINING 6 FIGURES)

Greenheart is a tropical timber-tree,¹ belonging to the laurel family, which has a world-wide reputation for extreme durability. The species grows in South America and some of the West Indian islands and is commercially exploited for home consumption as well as for export trade. In its native home it is used generally where a durable timber is required, it being resistant not only to wood-destroying fungi, but also to marine borers and white ants. Outside its habitat it finds its greatest use in marine construction, to which it is particularly adapted on account of its resistance to the teredo.

The wood is very hard, heavy (about 61 lbs. to the cubic foot when air dry), tough, very strong, and fine-grained. As in many tropical trees, annual growth rings are not distinguishable.

The proportion of sapwood in a log is usually high, ranging from 3 to 4 inches in thickness in trunks 18 to 24 inches in diameter. Trees under 12 inches usually consist largely of sapwood. It is said that dealers do not regard the sapwood as inferior to heartwood, but the tests below outlined indicate there is a marked difference.

Freshly-cut sapwood is pale-yellow, darkening on exposure; the heartwood may vary from pale-yellow to black. Under the microscope the wood appears very dense, being interspersed with numerous single or double vessels, whose cavities are frequently stuffed with cellular ingrowths, called tyloses (Plate 162, figs. 4, 5, 6). These tyloses, when very abundant, are said to give a darker appearance to the wood.

¹ Mell, C. D., and Brush, W. D. Greenheart. U. S. Forest Serv. Circ. 211. 1913.

The great durability of the wood has been mainly attributed to two factors, (1) the presence of the tyloses, which stuff the vessels and thus render them more difficult of penetration by fungus mycelium, and (2) the presence in the wood of certain alkaloids which may exert a preservative effect.

At least four alkaloids have been extracted from the wood and bark, among which may be mentioned bebeerine² (or biberine) of the formula $C_{18}H_{21}O_3N$, and nectandrine, $C_{20}H_{23}O_4N$. The former is said to be commercially exploited as a substitute for cinchona. It contains a methoxyl group, a phenolic hydroxyl group and a NCH_3 group.

The toxicity to fungi of these alkaloidal extracts from greenheart has not yet been determined by the writer, but it is the plan to make such tests later, in an effort to throw further light on the durability of this remarkable wood.

During 1913-14 the writer conducted a series of durability tests on both the heartwood and sapwood of greenheart timber. The material was sent to the Forest Products Laboratory, Madison, Wisconsin, from British Guiana for test purposes. The shipment consisted of a 13 by 13 inch square-hewn timber, upon which the bark was still adhering to the corners in strips an inch to an inch and a half wide. The sapwood was about two and a half inches thick, being largely confined to the corners, it being hewn away at the center of the faces.

Test blocks $\frac{5}{8}$ by $\frac{5}{8}$ by 2 inches long were sawed out from near the center to secure good heart material, while the sapwood specimens were cut from near the circumference at the corners, in many instances representing the extreme outer surface, and hence less than normal size on account of the wane (Plate 162, fig. 2).

Each block was tested singly in a large test tube $1\frac{3}{4}$ inches in diameter and 9 inches long, the sapwood and heartwood being tested against the same organisms. Seventy tube cultures were originally planned, using 35 species of wood-destroying fungi common to the United States, but certain failures incident to the experiment reduced this number somewhat.

² Henry, T. A. The plant alkaloids, pp. 414, 415. 1913.

The test blocks were oven-dried at 100 to 105° C. for 20 hours and weighed. To moisten again they were placed in a dish of tap water, brought to a boil, and allowed to cool.

The tube cultures were prepared by placing a layer of wet sterilized sphagnum moss in the bottom, followed by a layer of moist sterile sand up to about two-fifths the length of the tube. The test block was embedded in this sand for about one-half its length and surrounded by culture blocks of spruce or beech, the former being used in the case of fungi known to inhabit coniferous timber and the latter in the case of hardwood fungi. Over the whole was packed a layer of wet sphagnum. Tap water was then added to saturate the sphagnum and sand in the bottom and the tubes were then tightly plugged with absorbent cotton.

After sterilization of about 1 hour at 12 pounds steam pressure, the tubes were allowed to cool and were inoculated on August 28 and 29 with various wood-destroying fungi, among which are included many of the most active ones prevalent in the United States.

With the exception of *Merulius lachrymans*, which was placed in the incubator at 22 to 26° C., all the cultures were held at laboratory temperature, which varied considerably with the seasons. After one year the tubes were opened and the blocks examined. Plate 162, figs. 1 and 3, illustrate the method of test and the luxuriant mycelial development which was attained by the end of the test period.

Upon removal, the test blocks were oven-dried and re-weighed. Tables I and II present the essential data and results.

An examination of Table I shows that the heartwood of green-heart proved highly resistant, and in most cases practically immune, to all the fungi used, in spite of the fact that the organisms developed luxuriantly in the tubes. Very little effect on the wood was noted in a visual examination. Losses in weight under 0.5 per cent. are not recorded, as this may lie within the experimental error.

Table II shows a somewhat different state of affairs, for the

TABLE I
DURABILITY OF HEARTWOOD

Organism.	Oven Dry Weight (Grams).		Loss in Weight (%).	Growth of Organism.	Condition of Culture Blocks.	Condition of Greenheart Test Blocks
	Before Test.	After 1 Year.				
<i>Lenzites betulina</i> (L.) Fr. No. 629.....	15.89	15.72	1.1	Good.	Considerably rotted.	Not appreciably affected.
<i>Lenzites septaria</i> (Wulf.) Fr. No. 780....	15.72	15.12	3.8	Luxuriant.	Thoroughly rotted.	Slightly softened at lower end.
<i>Merulius lachrymans</i> (Wulf.) Fr.*						
Germany.						
<i>Merulius tremellosus</i> (Schrad.) Fr. No. 127	15.95	15.50	2.8	do.	Considerably rotted.	do.
<i>Fomes annosus</i> (Fr.) Cke.....Pa.	17.09	16.85	1.4	do.	Thoroughly rotted.	Not appreciably affected.
<i>Fomes everhartii</i> (Ell. & Gall.).....Wis.	16.37	16.35	.....	Poor.	Considerably rotted.	do.
<i>Fomes fomentarius</i> (L.) Fr.....Minn.	16.30	16.25	.....	Luxuriant.	do.	do.
<i>Fomes igniarius</i> (L.) Fr. No. 6254.....	16.69	15.60	6.5	do.	Thoroughly rotted.	Slightly affected.
<i>Fomes lobatus</i> (Schw.).....Ind.	16.79	16.75	.....	do.	Considerably rotted.	Not appreciably affected.
<i>Fomes pinicola</i> (Sw.) Fr. No. 6222.....	15.18	14.94	1.6	do.	Thoroughly rotted.	do.
	16.05	15.98	.....	do.	do.	Slightly affected in small spot at one end.
<i>Fomes roseus</i> (A. & S.) Fr. No. 6364.....	16.35	16.35	.....	do.	do.	Not appreciably affected.
<i>Polyporus adustus</i> (Willd.) Fr. No. 626..	16.87	16.90	.....	do.	do.	do.
<i>Polyporus obtusus</i> Berk.....Minn.	15.03	14.90	0.8	do.	Considerably rotted.	do.
<i>Polyporus resinus</i> (Schrad.) Fr. No. 1043	16.54	16.50	.....	do.	do.	do.
<i>Polyporus sulphureus</i> (Bull.) Fr. No. 6263	15.76	15.70	.....	do.	Thoroughly rotted.	do.
<i>Polystictus hirsutus</i> Fr. No. 6390.....	16.85	16.85	.....	do.	do.	do.
<i>Polystictus versicolor</i> (L.) Fr.† No. 639..	15.13	15.00	0.9	do.	Considerably rotted.	do.
<i>Trametes robinophila</i> Murr. No. 827....	13.48	13.32	1.2	do.	Thoroughly rotted.	do.
<i>Stereum fasciatum</i> Schw. No. 627.....	16.39	16.32	.....	do.	do.	do.
<i>Stereum gausapatium</i> Fr. No. 914.....	16.48	16.48	.....	do.	Considerably rotted.	do.
<i>Stereum rameale</i> Schw. No. 954.....	16.70	16.70	.....	do.	do.	do.
<i>Flammula polychroa</i> Berk. No. 888.....	16.18	16.15	.....	do.	do.	do.
<i>Lenitinus lecomtei</i> Fr. No. 945.....	16.27	16.10	1.0	do.	Thoroughly rotted.	do.
<i>Lenitinus lepidus</i> Fr. No. 6258.....	17.16	17.12	.....	do.	do.	do.

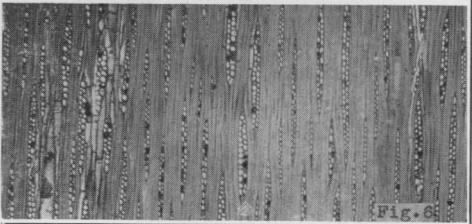
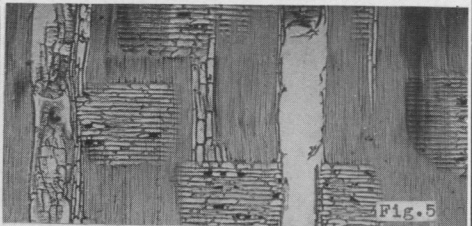
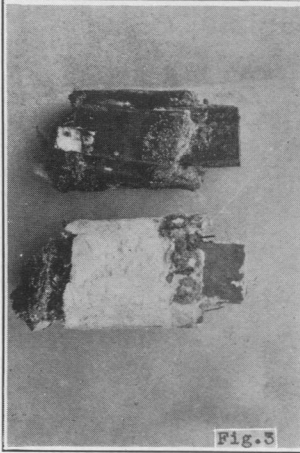
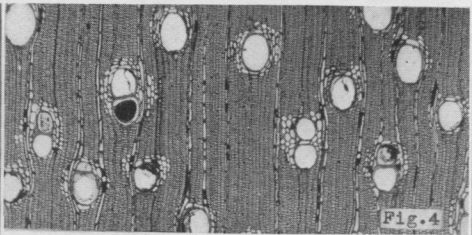
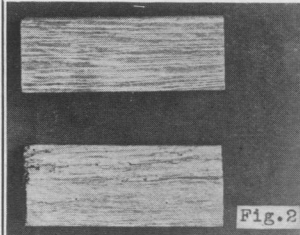
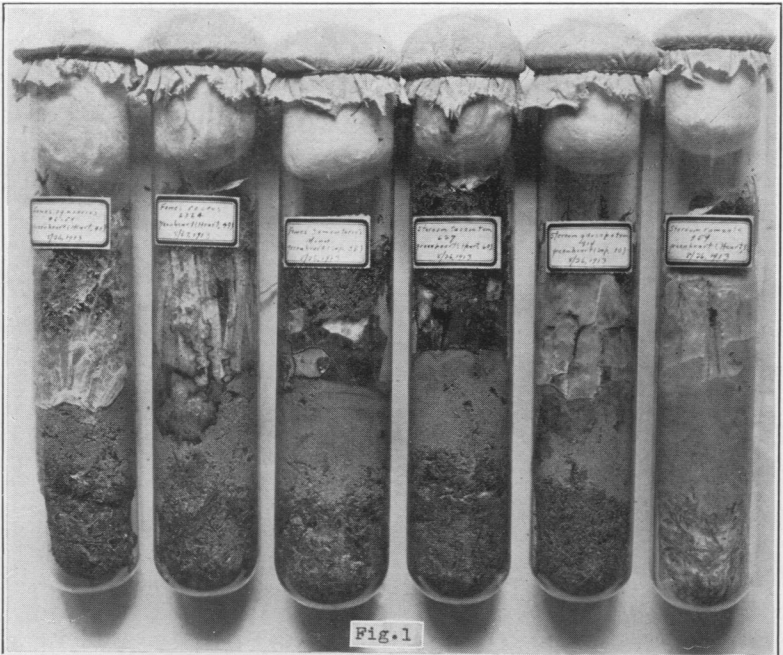
* Held in incubator at 22-26° C.

† Hole in bottom of tube allowed culture to dry out.

TABLE II
DURABILITY OF SAPWOOD

Organism.	Oven Dry Weight (Grams).		Loss in Weight (%).	Growth of Organism.	Condition of Culture Blocks.	Condition of Greenheart Test Blocks
	Before Test.	After 1 Year.				
<i>Lenzites betulina</i> (L.) Fr. No. 629.	8.79	8.40	4.4	Luxuriant.	Thoroughly rotted.	Slightly affected.
<i>Lenzites sepiaria</i> (Wulf.) Fr. No. 780.	10.80	6.80	37.0	do.	do.	Seriously rotted.
<i>Merulius lachrymans</i> (Wulf.) Fr.* Germany.	11.22	8.30	26.0	do.	Seriously rotted.	Seriously rotted at lower end.
<i>Merulius tremellosus</i> (Schrad.) Fr. No. 127	9.52	8.43	11.4	do.	Thoroughly rotted.	Considerably rotted at both ends.
<i>Fomes annosus</i> (Fr.) Cke. Pa.	14.65	14.45	1.4	Poor.	Considerably rotted.	Not appreciably affected.
<i>Fomes everhartii</i> (Ell. & Gall.) Wis.	14.18	13.60	4.1	Luxuriant.	Thoroughly rotted.	Bleached and somewhat affected.
<i>Fomes igniarius</i> (L.) Fr. No. 6254.	14.40	11.32	21.4	do.	do.	Considerably affected at lower end.
<i>Fomes lobatus</i> (Schw.) Ind.	12.93	9.80	24.2	do.	do.	Considerably affected.
<i>Fomes pinicola</i> (Sw.) Fr. No. 6222.	8.35	8.27	1.0	do.	do.	Not appreciably affected.
<i>Fomes robiniae</i> (Murr.) No. 859.	13.72	13.67	.....	Good.	Considerably rotted.	do.
<i>Fomes roseus</i> (A. & S.) Fr. No. 6364.	14.65	14.45	1.4	do.	do.	do.
<i>Polyporus obtusus</i> Berk. Minn.	15.28	13.90	9.0	Luxuriant.	do.	Considerably affected at ends.
<i>Polyporus resinosis</i> (Schrad.) Fr. No. 1043	12.60	11.49	8.8	do.	Thoroughly rotted.	Considerably affected.
<i>Polyporus sulphureus</i> (Bull.) Fr. No. 6263	8.50	7.92	6.8	do.	do.	Considerably affected at lower end.
<i>Polystictus hirsutus</i> Fr. No. 6390.	12.60	11.55	8.3	do.	do.	Slightly affected at lower end.
<i>Polystictus prolificans</i> (Fr.) Wis.	10.71	10.17	5.0	do.	do.	Considerably affected at lower end.
<i>Polystictus versicolor</i> (L.) Fr. No. 639.	12.87	11.47	10.9	do.	do.	Considerably affected.
<i>Stereum fasciatum</i> Schw. No. 627.	13.65	13.55	0.7	do.	do.	Not appreciably affected.
<i>Stereum gausapatum</i> Fr. No. 914.	14.10	13.05	7.4	Good.	do.	Slightly affected.
<i>Stereum rameale</i> Schw. No. 954.	14.80	13.32	10.0	Luxuriant.	Considerably rotted.	Considerably affected at one end.
<i>Flammula polychroa</i> Berk. No. 888.	11.17	11.10	0.6	do.	do.	Slightly affected at ends.
<i>Leninus lecontei</i> Fr. No. 945.	13.03	10.75	17.5	do.	do.	Considerably affected.
<i>Schizophyllum commune</i> Fr. No. 885.	13.24	13.07	1.3	Poor.	Slightly affected.	Not appreciably affected.

* Held in incubator at 22-26° C.



DURABILITY OF GREENHEART

sapwood proved far less resistant. *Lenzites sepiaria* proved the most active organism, producing a loss in dry weight of 37 per cent. *Merulius lachrymans* stands next with a loss of 26 per cent. Six other fungi produced losses ranging from 10 to 25 per cent. The wood remained practically immune to only three of the twenty-three fungi used.

The fact that the sapwood is more susceptible to decay than the heartwood meets our natural expectations, as this is the rule with timbers in which the heart and sapwood are differentiated.

The point to be kept in mind is that the sapwood, being so much less resistant to decay than the heart, should be carefully considered in timber specifications which call for the best quality of durable material. Not alone is the sapwood moderately susceptible to the attacks of fungi, but it is also reported to be more readily attacked by marine borers, and hence is said to be less valuable for wharf construction.

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DESCRIPTION OF PLATE CLXII

- FIG. 1. Cultures in large tubes of six species of fungi, showing method of testing. Each tube contains a greenheart block surrounded by easily rotted culture blocks. After 1 year.
- FIG. 2. Greenheart test blocks, heartwood above; sapwood, with wane, below.
- FIG. 3. Greenheart block and beech culture blocks matted together by a heavy growth of mycelium at end of the test period. *Stereum fasciatum* above, *Polystictus hirsutus* below.
- FIG. 4. Photomicrograph of transverse section of greenheart wood. Note the compact structure and tyloses partially filling the ducts. (By courtesy U. S. Forest Service.)
- FIG. 5. Radial section of greenheart wood. (Courtesy of U. S. Forest Service.)
- FIG. 6. Tangential section of same. (Courtesy U. S. Forest Service.)